DESCRIPTION

OF

Edison Electric Light

PLANT,

OF

BROCKTON, MASS.

[From Electrical Review.]

Incandescent Electric Lighting;

WITH SPECIAL REFERENCE TO AND

DESCRIPTION

OF THE

EDISON ELECTRIC LIGHTING STATION

OF

BROCKTON, MASS.

BY

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EDITOR OF THE ELECTRICAL REVIEW:

The world is beginning to realize that the problem of producing light by electric agency, for so many years the dream of scientific enthusiasts, is rapidly reaching so clear a solution that the public is not only to be generally interested in the improved illumination by the new methods, but will soon be offered a share in the management of numerous local enterprises, and the pecuniary advantage, which is now shown to be only a question of a short time.

The fact is perhaps not generally appreciated that two per cent. of the entire live capital of the country is invested in the business of illumination, a larger proportion than is represented by any other industry but that of transportation. The interest manifested through the columns of journals which, like the *Review*, have for some years devoted their energies largely to popular education in electric lighting, has shown of late that the time is ripe for presenting the prospects for future investment in this direction, so far as they are indicated by the outcome in plants only recently established.

The field of central station

LIGHTING BY INCANDESCENCE

is comparatively untrodden. In all the United States only four systems are in operation where the distribution of electric currents for light is effected through underground conductors after the general plan pursued by the gas companies. And as on this basis all large installations will doubtless be inaugurated, and to it all of much importance must come, it may be interesting to notice the general results, both favorable and unfavorable, realized in the old-

est of these four systems (outside the experimental plant in your own city) at

BROCKTON, MASS.

Here the Edison, as yet the only system of central station lighting by low tension currents, was offered to the public Oct. 1. 1883. As might reasonably be expected, some grave mistakes were made in the general policy first inaugurated.

For instance, in a manufacturing city where land (as near the centre of trade as the station of an incandescent plant should be) is valuable, and room with power is always at a premium, a building should always be so constructed that the second floor and those above may be readily rented. The extra cost of an additional story or two is insignificant as compared with the advantage secured during the early years of the enterprise. In Brockton a second floor, favorably located for a shoe factory, and the size of the original Edison station, 50x65 feet, rents for $300 to $500 per year, and power for $75 to $100 per H. P. The Edison building was however devoted only to the illuminating business, while the station of the Thomson-Houston company, 60x80 feet, since erected, has paid a good income on its entire cost by the rental of two floors with about ten horse-power, at upwards of $2000 per year.

Inexperience in the

MECHANICAL DETAILS

of installation resulted in faulty construction, especially in the vital matter of laying the underground conductors, and a reliable service was secured during the first six months in the face of electrical complications growing out of these errors, which have not been repeated in later systems, and need never be encountered in future.

The sectional boilers first installed have proved less economical and satisfactory than a tubular boiler added

last summer. Some reasons for this result will be noted later on.

An exhaust injector, supplying water from the street mains to the boilers against a steam pressure of 100 pounds, at a temperature of 150° to 160° was used for the first six months. Its intermittent action, necessitating constant watchfulness, proved a decided drawback to its usefulness where the duties of engineer, dynamo and regulator attendant and fireman, devolved upon one man. The use of the National heater, which was finally secured, effected a saving of 5 to 7 per cent. in fuel by supplying the feed water at 210° to 212°, the pump maintaining a nearly constant level in the gauges.

The attempt to use short belts obliged them to be run so tight that extra oil, of higher cost than would otherwise have been necessary, was demanded, and even then the loss of power was shown by a degree of heat at the bearings of the armatures, calling for a constant application of water, and accompanied, in the case of a heavy load, by a notable pulsation of the lights.

A SMALL INITIAL BUSINESS.

The wheels were started with a small number of lamps connected, less than one-quarter of the quota required to pay expenses, and at a time of year when the long hours of winter lighting when a meter system should show its best work, were so close at hand as to pass before this quota was secured, thus obliging a determined effort to increase rapidly the patronage in order to prevent the entire year's record from being unfavorable and discouraging.

Customers were expected, from the first, to bear the entire cost of wiring their residences and places of business, purchasing the earlier and more expensive styles of electroliers, or adapting their gas or other fixtures to the new light, even before the test of time had convinced the public of its reliability and adaptation to their necessities or convenience.

The Illuminating Company attempted to do their own

WIRING OF BUILDINGS,

and found themselves in the position which a gas company would occupy if endeavoring to carry on both the business of manufacturing gas and that of piping. To the exploiting of a rapidly growing industry, demanding all their best efforts, was added the care of a large stock of supplies and patented devices, and the necessity of meeting a demand for a special class of mechanics. It is not strange that in this department mistakes were made which have since been corrected at considerable cost. The result was the forming of a separate organization, to take the business of inside wiring entirely into their hands, latterly known as the New England Wiring Company. Acting in harmony with the Illuminating management this accessory body did good work in canvassing the field, securing customers in all directions, placing some of the most elaborate fixtures, and showing the most varied and attractive applications of the Edison system in Brockton's stores and residences, which are to be found in any American city. Finally, with increased experience in the intricate and often perplexing detail of the work, the Wiring Company extended its field from the strictly local basis on which it started, and within the past year has done varied service in Providence, Attleboro, Andover, Manchester and Boston for isolated plants, and at Laconia, N. H., for the nucleus of a central station system. Thus, as an outgrowth of disadvantageous circumstances, sprung an auxiliary which has proved a most valuable aid to the progress of the enterprise, and whose experience may be made available in future systems.

All the disadvantages here only hinted at combined to present so severe a test of the real money-making capabilities of the system that special force attaches to the fact that the legitimate running expenses of the station for the year ending September 30, 1884, together with some extraordinary outlays not likely to become necessary

in future, were paid by the income, and that the returns for the five months since that date indicate that a dividend will be earned the present year.

It will be readily understood that this result could not have been secured without intelligent and faithful management of the central station machinery, persistent efforts for the extension of the system and the increase of the number of customers, and watchfulness of the needs and preferences of all connected with the wires, and of the conditions which insure reliability of the service. Nor must the fact be overlooked that the business enterprise which always creates enthusiasm among Brockton merchants over the introduction of "a good thing," played no small part in the instantaneous success and rapid adoption of the new light. The experience now gathered, and applied the past winter to the operation of the system, will doubtless be fruitful of regularly gratifying results in future, and offer substantial encouragement to those debating the development of similar plants. A few other

SCRAPS OF HISTORY

and experience will perhaps be valuable to inquirers.

Number of 10-candle Lamps at starting station,	200
" connected Oct. 1, 1884, ...	2000
Population of Brockton, Jan. 1, 1885 (about)	20,000
Price of Gas, Oct. 1, 1883, ...	$2.25
Present price, ...	2.00

Price of 10-candle Edison Lamp (equivalent to average 5-foot gas burner) 1 cent per hour.

Cost of Power, (about) $60 per H. P., for the first year of 365 days of 10 hours.

Average H. P. used in light production for the year 1884, 365 days of 13 hours each, ...	40
Number of Edison 10-candle Lamps supplied with current, per indicated H. P., ...	10

estimated for a 1600-light underground plant (corresponding with perhaps 3000 lamps actually installed) in a town or small city with fairly compact business district.

Capital, covering franchises for central station and isolated lighting, complete installation of plant with single set of machinery, and cash $5,000 for construction and other outlays during first year after starting station.	$55,000
Average Running Monthly Expenses of plant, when 2500 10-candle Lamps are installed, and 1000 in actual average use, say four hours every day (engines running from dark to daylight) :—	
Coal, 3 parts screenings, (say $3.25 per net ton,) and one part Cumberland, (say $4.75,) using Jarvis furnace, ...	$200.00
Oil and Waste, ...	17.00
Water, 125,000 gallons, say twenty cents per 1000 gallons, ...	25.00
Lamps, ...	150.00
Salaries, Manager, Metre man, Engineer and Fireman, say, ...	250.00
Average depreciation 5 % per year on $25,000,	104.00
Insurance, $20,000 at 1%	17.00
Taxes, ...	30.00
Incidentals, including meter supplies, $10.00, Telephone, $4.00, Stationery, $3.00, and Traveling, $5.00, ...	22.00
Monthly Total, . . .	$815.00
Gross Income, 4000 Lamp Hours per Day, .	$1200.00

Net Profit per year on this monthly average, $8\frac{1}{2}$% on capital stock.

The above estimates, though based upon the experience of the Brockton plant, do not in several respects agree with the results there secured. They rather indicate what should be and what may be attained, under or-

dinary circumstances, if proper provision for reasonable economy is made in construction of the station.

THE ELECTRICAL MACHINERY

of the Brockton station has, in the main, proved so satisfactory as to leave little to be desired which in the present stage of scientific progress it seems possible to supply. Very recently some modifications of the 450 light dynamos have brought their capacity fairly up to 400 amperes and 125 volts, thus enabling them to provide for the loss of about 15 per cent. in feeders, mains, and inside wiring of buildings, and still maintain 800 10-candle Lamps requiring 110 volts to develop their normal light. The fact that this result is obtained while reducing the speed from 1200 to 900 revolutions per minute is one of the most gratifying recently brought out. This makes it possible to use 58-inch driving pulleys on the engine (in place of 66-inch) at 250 revolutions, and 16-inch on the dynamo (instead of 14-inch), and while retaining as available the normal power of the engine, and all the sensitiveness of its centrifugal governor, secure the maximum work of the dynamo with less heating of the bearings, less oil, and less wear of the commutator and brushes.

It has been objected to the methods of the Edison central stations that no automatic regulation is provided. Without doubt this will be secured, but those who criticize appear to forget that a compound winding, which some have loudly proclaimed as a panacea for all incandescent ills, simply aims to maintain a constant potential *at the dynamo*, (and of course practically, in isolated systems, throughout a building) while this is exactly what a central station machine must not do, as varying loads are accompanied by varying percentages of drop in electro-motive-force between the dynamo and the objective point, the lamp.

The delicate Edison indicator shows the watchful engineer a variation of 1 per cent. in the number of lamps in use, and in the case of a large theatre whose lights may

aggregate from 25 to 50 per cent. of the entire load on the system, it has been found convenient to use a special wire connecting a small signal bell and key on the stage with a mechanical gong at the station end, and enabling either party by a code of signals, to ascertain at any moment the circumstances of the other, and give warning of sudden changes.

The accuracy of the Edison meter system has been the subject of much doubt. Its practical operation has even been put upon the level of the incorrigible gauger of carburetted hydrogen. Without question it is as easy to make an electric meter lie as a gas meter, but it is certainly vastly easier to make it tell the truth. As a general rule customers do not growl. Numbers of them have kept track of their electric light consumption, making a daily note of the lamp-hours, and in some cases laying aside money for the payment of the bills. Such have uniformly been gratified at the accuracy of the meter record, and learned to put confidence in it, while it is as uniformly the case that the chronic growler knows nothing definite regarding his use of light.

The City Theatre, opened in October last, was the first in this country to be lighted by incandescent lamps by current from a central station metered like gas. The 500 lights distributed over the stage, auditorium, corridors, dressing rooms and approaches, form the only method of illumination, and as a matter of additional precaution, current is received from two services, drawing from the mains at points widely separated. In a smaller theatre since fitted, and in two large skating-rinks, well-grounded confidence has entirely excluded other methods of general lighting. The satisfaction realized as to quality and quantity is emphasized by the fact that after months of service by meter, the rinks have contracted with the Edison company for the season on mutually agreeable terms. The managers of the larger theatre, where the use of the light is intermittent, manifest no disposition to find fault with the meter bills.

The electrical conditions necessary for a perfect tube system have been so closely met, and the work of manufacture is now so carefully carried out, that in a year and a half of actual service no instance of trouble within the length of a 20-foot tube has ever arisen. Watchfulness of the mechanical work of laying these tubes and subsequent attachment of services will effectually prevent unsatisfactory working.

THE STEAM PLANT.

It would be difficult to find an engine better adapted to the exactions of central station work than the Armington & Sims automatic cut-off, with the latest improvements, including relief valves, preventing the possibility of accident from water in the cylinder. With fairly even pressure of steam, the regularity of its action under the sudden changes of load which constantly occur, is surprising, and when its full power is brought out in a case of short-circuiting of the main conductors, when in the twinkling of an eye its burden may be multiplied perhaps ten-fold, perhaps twenty-fold, its performance excites admiration and constitutes one of the safeguards of the system, enabling the dynamos to melt out the obstruction and continue their work. The high-speed engine, belted direct to the dynamo, may justly be regarded as one of the corner stones of the successful electric light station of the future.

The rapid growth of the system made it advisable last spring to reinforce the $8\frac{1}{2} \times 10$ engine running 350 revolutions, and the $14\frac{1}{2} \times 13$, speeded to 250 to 265, by a second machine of the latter size, with its accompanying 800-light dynamos. Closely following this came an increase of the boiler capacity of the station last summer. After careful consideration this was accomplished by the placing of a 125-H.P. steel tubular boiler by the Jarvis Engineering Company. This course was pursued because of the following unfavorable points developed by the two Babcock & Wilcox sectional boilers of 73 H. P. each, which were first supplied:

1. Slow action in raising steam. The tubular now in use shows 80 pounds (from cold water) from twenty minutes to half an hour sooner than the sectional.

2. Difficulty in recovering pressure when started downward by a sudden increase of load. This probably results from the extremely limited steam room, and small body of water exposed to the fire. Where, as in electric lighting, it is suicidal to stop the wheels during a run, this point becomes a vital one, especially when one man is charged with a variety of duties.

3. Uncertainty as to the level of the water. It has often happened that after opening the gauge-cocks, the water fails to reappear for some time, and leaves the fireman in suspense as to the real state of the case. The steam is also less dry and of course less effective than in tubular boilers.

4. Amount of care necessary. The frequent cleaning of the outside of the tubes by steam jet should be supplemented by periodical inspection of their interior, a task which, as the plugs which close them speedily rusted in, has become practically impossible in this station between the hours of shutting down in the morning and starting again toward night.

5. Greater economy of tubular form with Jarvis boiler setting. The tests made elsewhere, on which this judgment was based, were supplemented in December last by a very careful trial here, of which the following figures give the

COMPARATIVE RESULTS.

	Steel Tubular Boiler and Jarvis Furnace.	Babcock & Wilcox Boilers.
Date of Tests,	Dec. 3, '84.	Dec. 5, '84.
Duration of Tests,	16 h. 7 m.	16 h. 5 m.
Grate Surface, Sq. Ft.	36	42
Kind of Fuel used,	1 part Soft Coal, 3 parts Screenings.	Clear Soft Coal.
Average Steam Pressure, lbs.	85.16	87.22
Average Temperature of Feed Water, °F	209.16	208.38
Pounds of Fuel consumed, { 200 lbs. wood figured equal 100 lbs. soft coal. } Screenings, lbs.	2,250	
Pounds of Fuel consumed, { 200 lbs. wood figured equal 100 lbs. soft coal. } Soft Coal, lbs.	850	3,800
Pounds of Ashes and Refuse,	400	285
Pounds of Combustible,	2,700	3.315
Per Cent. of Ashes and Refuse,	12.9	7.5
Pounds Water Evaporated under Actual Conditions,	32,458	37,004
Equivalent Evaporation from and at 212°	33,724	38,521
Pounds Water Evaporated per pound of Coal under Actual Conditions,	10.47	9.74
Pounds Water Evaporated per pound of Coal from and at 212°	10.88	10.01
Pounds Water Evaporated per pound of Combustible Actual Conditions	12.02	10.53
Pounds Water Evaporated per pound of Combustible from and at 212°,	12.49	10.96
**Cost of Fuel consumed,	$5 85	$8.56
Pounds Water Evaporated @ 212° for $1.00 worth of Fuel,	**5,765**	**4,500**
Economy shown by use of Tubular Boilers, Jarvis Furnace and Screening Mixture,	22%	
H. P. developed by indication of Armington & Sims engines at comparative times. 5 o'clock, P. M.	96 H. P.	94 H. P.
6 " "	96 "	105 "
7 " "	92 "	92 "
From 9 P. M. until 7 A. M. the power varied, being at times as low as 10 H. P. 8 " "	104 "	112 "
9 " "	104 "	128 "
Factor of Evaporation,	1.039	1.041

**Cost of Coal, { Soft Coal, $5.05 per 2240 lbs. Screenings, 3.50 per 2000 lbs.

PRACTICAL POINTS OF INTEREST.

The central station system shows in practice all the advantages of isolated plants with one or two important additional features. The steadiness of the light should in most cases be far superior, while the presence of duplicate boiler, engine, and dynamo power, guards against the liability of interruption which exists in isolated installations.

The Edison light is found to be almost equal to the arc in its power of discrimination in color and texture of goods. There are several Brockton merchants who affirm that they have no hesitation in matching, by the ordinary light in their stores, all but the most delicate of shades, and these are shown with great distinctness by the use of several lamps, or by a single lamp of high power, so arranged on the counter under an opaque shade as to cast its full brilliancy upon the goods close at hand.

Brockton shows some novel and beautiful effects in residence lighting, the arrangement of switches in some instances controlling all the lamps in the house from one or two central points, for greater convenience in case of fire or midnight visitations. Fascinating moonlight effects are produced by placing lamps on verandas, where the light will stream through open windows in the warm evenings of summer.

In a central engine house nearly forty lamps, in sleeping rooms and over steamers, are automatically lighted at the first stroke of an alarm, the same mechanism assisting to liberate the doors of all the stalls, and insure the immediate presence of the trained horses at the poles of the engine. One church has been fitted with elaborate fixtures, and in the halls, rinks and theatres the three-wire system has been carried into the larger electroliers, securing the control of half the lights at a time, as is often desirable, with a minimum outlay of wire and a double safeguard against interruption of the service.

HINTS TO PROMOTERS.

It may not be out of place in closing this already long

communication, to suggest a few points of importance to syndicates or individuals thinking of starting stations this year.

1. The choice between the overhead and underground plans should be determined by the feeling of the people regarding heavy pole lines in or near the principal streets, the existence of present lines or rows of trees, the feasibility of placing poles on private land along the rear lines of street lots, and the prospective size of the system. Very few cities can be adaquately served by overhead systems. Housetops should be avoided, and poles, when used, should be only from 90 to 110 feet apart, for heavy lines carrying feeders. The overhead conductors, if adapted to the place, will cost from one-quarter to one-third as much as the underground.

2. If you contemplate an underground system, come to Brockton if possible, and study the results where present knowledge has been gained largely by home experience. If an overhead installation is to be preferred, visit the plants in Pennsylvania or Ohio.

3. If an experienced manager is not available, secure during construction and the early month or two of operation, the best practical knowledge of the three-wire system which money will furnish. Don't make the mistake of attempting to cut running expenses the first year by using men of questionable ability. No well-informed Edison man is disposed, as Mr. Edison has well expressed it, "to make mysteries of plain things," but no Edison station will run itself and earn an enviable name. The care and judgment exercised in manipulating the station machinery, the meters, and the lamps, are of paramount importance to the early reliability of the service, and its lasting reputation. When numbers of good men have become familiar with the system, it will be time to choose between them. Get the best while the first few months' service is moulding public opinion.

4. If possible, combine the arc and incandescent systems under one management and one roof. One steam plant and one force of men can care for both, and

no better training for the handling of the dangerous high tension currents can be found than that which teaches the proper care of low tension conductors. If there is money to be made in electric lighting, it is to be found in a system where an arc lamp like the Thompson-Houston lights the street, and the Edison glows from the show-windows, while the same fires make steam for both, or the same turbine moves the common shaft.

5. One cardinal idea should be borne in mind in the work of construction. Selling lights by electric methods is, in effect, selling distributed power. Hence the first cost of power and the loss of it in transmission are most important factors in the grand result. It has been shown how the management of the Brockton station have succeeded in reducing the cost of their coal and increasing the efficiency of their steam plant. In the distribution of the current the principle enunciated by Sir William Thomson and others that "the additional running expense due to the resistance of conductors should equal the interest on their first cost" applies with certain modifications to the Edison system, and experience has shown what form those modifications should take.

6. Don't allow the spring to pass before your plans for this year are well outlined and in process of execution. The American capitalist, unlike his more moderate English cousin, is impatient for immediate dividends, and the results of the first year's run seem abnormally important to him. If a good showing is to be made for the year ending July 31, 1886, there is no time to be lost in getting started, for the land should be bought, conductors figured, made and laid, station built and equipped, and a good number of lamps wired for before the 1st day of August. Starting then, the machinery will be worked down to smooth bearings, the public convinced of the reliability and other merits of the light, and several hundred lamps connected by September 1st, when the harvest time of the incandescent plant commences. By April 1st of next year, if good judgment has prevailed and success has smiled, the list will be large enough to carry the expenses through the short hours of summer lighting, and the Edison system be shown to be a practical success with its patrons from the outset, and likely to insure a commercial return to its stock-holders within a reasonable period.

W. J. JENKS.

Brockton, Mass., March 24, 1885.